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NONWOVEN FABRIC

BACKGROUND OF THE INVENTION

The present invention relates to nonwoven fabric that can easily be torn to arbitrary sizes by hand. The nonwoven fabric of the present invention is particularly suitable for cleansing use like a cleaning sponge, etc., cooking use like a cooking sheet, etc. or wiping use, etc. When used for cleansing, it is particularly fit for cleaning a kitchen, a car, a toilet, a human body, a bath tab, and so forth.

Nonwoven fabric is, in nature of the process of making, generally made up of continuous fibers or fibers about 50 mm long. In order to tear such nonwoven fabric, the fibers must be broken. Therefore it is difficult to tear it by hand. Further, being attributed to the process of making, the degree of fiber orientation differs between the machine direction and the transverse direction so that the tearability differs depending on the direction. It is less difficult, in general, to separate the constituent fibers apart and tear off nonwoven fabric along the machine direction than along the transverse direction, because, in order to tear along the transverse direction, the fibers must be broken and cut. As a result, if a user intends to tear nonwoven fabric along the transverse direction, the tearing direction tends to be deviated to the direction of easy tearing.

Nonwoven fabric can have perforations at which a piece can be torn off easily as with the case of a wet tissue. However, the size of a piece torn off is limited to the interval of the perforations, and it is very difficult to tear off a piece of desired size at a position other than the perforations.

A cleaning sheet includes a wipe for wiping off dirt. Conformable to the contour of an object of cleaning, a wipe can achieve cleaning of curved portions or narrow portions easily. A wipe made of paper, being easily tearable by hand, is convenient to use. However, conventional wipes are unsatisfactory in working up a good lather or scouring off dirt.

Apart from wipes, cleaning articles generally called sponges are also known, which

are not sheets and comprise natural sponge or a porous body. A sponge comprising a nonwoven fabric to which an abrasive-containing resin has been applied and hardened is also known as a cleaning article with improved scouring performance. A sponge is excellent in working up a good lather but is not fit for cleaning narrow portions such as gaps. A sponge comprising a nonwoven fabric to which an abrasive-containing resin has been applied and hardened, being a sheet, is fit for scouring dirt off narrow portions such as gaps but is less conformable to the curved surface because of the hardness of the cured resin. Besides, these spongy articles are not so convenient to use in that they cannot be torn by hand unlike paper-made wipes.

Japanese Patent Laid-Open Nos. 60761/98 and 61614/99 disclose a sheeting material for wipes and absorbent articles which comprises air-laid nonwoven fabric made of relatively short fibers. However, the air-laid nonwoven fabric disclosed is intended to be used as it is sized and cannot be easily torn off by hand into a piece of desired size.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide nonwoven fabric which can easily be torn off to arbitrary sizes by hand and has no difference in tearability between the machine direction and the transverse direction.

Another object of the present invention is to provide sponge-like nonwoven fabric suitable as a cleaning sheet.

Still another object of the present invention is to provide nonwoven fabric having the properties of lathering a detergent and scouring off dirt.

Yet another object of the present invention is to provide nonwoven fabric conformable to the contour of an object of cleaning.

The above objects of the present invention are accomplished by nonwoven fabric having a basis weight of 30 to 200 g/m^2, a thickness of 0.5 to 5 mm, and a tear strength of 0.1 to 3 N, and manufactured from fibers having a length of 2 to 10 mm and a fineness of 1 to 100 denier by air-laying the fibers to form a web and thermally bonding the fibers at the intersections thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 schematically shows the position of tearing the nonwoven fabric according to the present invention;

Fig. 2 is a schematic view of the nonwoven fabric according to the present invention having depressions;

Figs. 3A, 3B, 3C, 3D and 3E each schematically illustrate an embossed pattern made on the nonwoven fabric according to the present invention; and

Figs. 4A, 4B and 4C each represent the manner of using the nonwoven fabric according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments for carrying out the present invention will be described hereunder.

The nonwoven fabric of the present invention is prepared by forming a web of fibers having a length of 2 to 10 mm and a fineness of 1 to 100 denier by an air-laying method, in which disentangled fibers are carried by the flow of air, passed through a metal net or a screen having fine pores, and built up on a wire mesh to form a web, and thermally bonding the intersections of the fibers. Unlike nonwoven fabrics made by carding, etc. in which fibers are likely to be orientated along the machine direction, nonwoven fabric made by air-laying can have fibers orientated in three directions, i.e., the machine direction, the transverse direction, and the thickness direction and is therefore tearable in every direction, showing no difference in tearability between the machine direction and the transverse direction (i.e., no anisotropy in tearability). The web being formed of short fibers 2 to 10 mm long with their intersections thermally bonded, at least one thermally bonded joint of fibers exists within 10 mm in every direction without fail. The separability between bonded fibers can be controlled by controlling the adhesion of the heat-fusion joints so that the nonwoven fabric can be torn apart by hand with ease.

The nonwoven fabric made by air-laying, being bulky and elastic, secures a sufficient distance among fibers to hold a large amount of air in the interior thereof. As a result,

where the nonwoven fabric of the invention is used, for example, as a cleaning sheet saturated with a detergent, the detergent is finely mixed up with air to lather well. Further, because the fibers are apt to be orientated in the thickness direction, the nonwoven fabric exhibits high performance in scouring out dirt when used as a cleaning sheet, for example. The scouring effect would be further improved by using rigid and/or thick fibers.

The nonwoven fabric of the present invention is sponge-like. The term "sponge" as referred to herein denotes a material made of natural sponge or a porous body which is not intended to wipe up dirt but has a function for getting stains being easily washed out with water. For the nonwoven fabric to be "sponge-like" is intended to mean that the nonwoven fabric is made of a material other than natural sponge or a porous body and has the above-described function.

Since the nonwoven fabric is made up of fibers having the above specified length and fineness and formed by the air-laying method, the distance between fibers in the nonwoven fabric is to range preferably 50 to 1000 μm, still preferably 90 to 500 μm. For the same reasons, the nonwoven fabric preferably has a specific capacity of 20 to 60 cm^3/g, particularly 20 to 40 cm^3/g, which is as large as that of a sponge.

The distance (μm) between fibers is calculated as follows.
Where the nonwoven fabric consists of a single kind of fiber,

$$\text{Distance between fibers} = 10^6 \times \sqrt{\frac{Atd}{9000w}}$$

wherein A: area (m^2) of nonwoven fabric;
t: thickness (m) of nonwoven fabric (under 980 Pa load);
w: weight (g) of nonwoven fabric; and
d: fineness (denier).

Where the nonwoven fabric consists of n kinds of fiber,

$$\text{Distance between fibers} = 10^6 \times \sqrt{\frac{At}{9000} \frac{1}{\frac{w}{100} \sum_{i=1}^{n} \frac{f_i}{d_i}}}$$

wherein d_i: fineness (denier) of the i-th kind of fiber; and

f_i: mixing ratio (%) of the i-th kind of fiber.

The specific capacity (cm^3/g) is calculated from the following equation:

$$\text{Specific Capacity } (cm^3/g) = 10^6 \times \frac{At}{w}$$

wherein A, t, and w are as defined above.

The fiber used in the nonwoven fabric has a length of 2 to 10 mm. If the fiber length is shorter than 2 mm, the fibers are liable to fall off the nonwoven fabric. If the fiber length is longer than 10 mm, the fibers tend to entangle with each other before passing through the screen in the web formation, resulting in a difficulty in forming a uniform web. A desirable fiber length is 3 to 8 mm, particularly 4 to 6 mm, with which fall-off of the fibers from nonwoven fabric can be prevented with more certainty, and a more uniform web can be formed.

The fiber used in the nonwoven fabric has a fineness of 1 to 100 denier. If the fineness is less than 1 denier, it is difficult to form a uniform web because the fibers have poor freedom and get entangled in the screen in the web formation. If the fineness exceeds 100 denier, the resulting nonwoven fabric has a hard texture and is non-uniform, and also a high basis weight is required, which increases the production cost.

Where the nonwoven fabric is used, for example, as a cleaning sheet, fibers with a greater fineness will provide a harder sheet, which is advantageous for scouring performance, but too great a fiber fineness would result in too a long distance between fibers, which is disadvantageous for a detergent to infiltrate into the sheet with affinity. Also, a hard sheet is difficult to crumple to lather a detergent or soap up. Accordingly, it is preferred for the fibers to have a fineness of 3 to 100 denier, particularly 3 to 65 denier, especially 6 to 32 denier. For the fibers to have a fineness within the preferred range is also advantageous for obtaining a more uniform web and a more uniform nonwoven fabric.

Where the nonwoven fabric is used, for example, as a cleaning sheet, the fiber fineness can be selected from the range specified above in accordance with the particular uses of the cleaning sheet. For instance, for use in a kitchen in washing dishes or kitchen utensils, 3 to 65 denier is preferred. From the standpoint of producing a good lather with the sheet saturated with a dishwashing detergent, 3 to 32 denier is still preferred. From the standpoint of improving dirt scouring properties, 10 to 65 denier is still preferred. For use as a cleaning sheet for human bodies, 3 to 10 denier is still preferred taking into consideration good lathering of soap and prevention of skin irritation. For use as a cleaning sheet for car bodies, 3 to 65 denier is still preferred for preventing scratches.

The fibers may be either crimped or not or may be strand cut fibers. The crimped fibers may have any of two-dimensional forms such as a zigzag form and three-dimensional forms such as a spiral form and an Ω form.

The intersections of the fibers in the air-laid web are thermally bonded by a prescribed means. Considering that the nonwoven fabric is to be torn off by breaking the thermally bonded joints of the fibers, it is preferred that the thermal bonding be thermal fusion of thermally fusible fibers comprising thermoplastic resins or thermal adhesion with thermally fusible powder comprising thermoplastic resins or thermosetting resins. The means for achieving thermal bonding using the thermally fusible fiber or powder are not particularly limited and include a tunnel drier, a hot air drier, a heated cylinder, infrared rays, embossing under heat or remaining heat, and the like. The thermal bonding in these means can be carried out either under pressure or no-pressure.

The fibers to be used are selected appropriately in accordance with the mode of thermal bonding. Where the thermal bonding is of thermally fusible fibers, thermally fusible fibers comprising a single kind of, or a mixture of two or more kinds of, thermoplastic resins, etc. or thermally fusible conjugate fibers are selected.

The thermoplastic resins which can constitute the thermally fusible fibers comprising a single kind of, or a mixture of two or more kinds of, thermoplastic resins include polyolefins, such as polypropylene, high-density polyethylene, medium-density polyethylene, low-density polyethylene, linear low-density polyethylene, and crystalline propylene

copolymers comprising propylene and α-olefins; polyamides; polyesters, such as polyethylene terephthalate, polybutylene terephthalate, low-melting polyesters comprising a diol and terephthalic acid and/or isophthalic acid, etc., and polyester elastomers; and fluoropolymers.

The thermally fusible conjugate fibers are composed of resins having different melting points, i.e., a low-melting resin and a high-melting resin, the low-melting resin forming at least part of the fiber surface. Illustrative examples of the low-melting resin/high-melting resin combination are high-density polyethylene/polypropylene, low-density polyethylene/polypropylene, polypropylene/ethylene-butene-1 crystalline copolymer, a high-density polyethylene/polyethylene terephthalate, nylon 6/nylon 66, low-melting polyethylene/polyethylene terephthalate, polypropylene/polyethylene terephthalate, and low-melting polyethylene terephthalate/ polyethylene terephthalate.

The form of the thermally fusible conjugate fibers can include a side-by-side form, a core/sheath form, an eccentric core/sheath form, a multilayer form having three or more layers, a hollow side-by-side form, a hollow core/sheath form, an odd-shaped core/sheath form, a sea-island form, and so forth, in which the low-melting resin forming at least part of the fiber surface. Preferred of these thermally fusible conjugate fibers are those of side-by-side, core/sheath or eccentric core/sheath form in which at least one thermoplastic resin selected from high-density polyethylene, linear low-density polyethylene, and an ethylene-butene-1 crystalline copolymer is used as a low-melting resin, and polypropylene or polyethylene terephthalate is used as a high-melting resin.

As long as thermal bonding is achieved by the thermally fusible fiber or thermally fusible conjugate fiber, it is acceptable to use fibers other than the above-described thermally fusible fiber or thermally fusible conjugate fiber, whose length and fineness fall within the above specified respective ranges. Useful other fibers include natural fiber, such as pulp, regenerated fiber, such as rayon, carbon fiber, metal fiber, glass fiber, ceramic fiber, and the like.

Where the thermal bonding is by the thermally fusible powder comprising thermoplastic or thermosetting resins (this bonding technique is generally called powder

bonding), the material constituting the fibers is not limited to thermoplastic resins and can include natural fiber, such as pulp, regenerated fiber, such as rayon, carbon fiber, metal fiber, glass fiber, ceramic fiber, and the like. Materials of the thermally fusible powder include polyethylene, ethylene-vinyl acetate copolymers, ionomers, non-stretched polypropylene, nylon, polybutadiene, ethylene-propylene random copolymers, adhesive phenolic resins, and urea resins. The thermally fusible powder is preferably used in an amount of 5 to 30% by weight of the total weight of fibers.

Where the powder bonding method is adopted by using the above-mentioned fibers and resins, there may be a fear, in some uses of the cleaning sheet, that the sheet is capable of scouring stains off the surface of an object of cleaning but scratches the surface. Hence, considerations should be given, in choosing the fibers and the resins, to not only the scouring performance but prevention of scratches to an object of cleaning.

Whatever mode of thermal bonding is used, the fiber constituting the nonwoven fabric can comprise two or more kinds of fibers which may have the same or different fiber lengths and/or finesses as far as the fiber lengths and the finenesses are within the above specified respective ranges. This does not mean to exclude use of fibers whose length and/or fineness are out of the above specified ranges as far as the effects of the present invention are not impaired.

In using two or more kinds of fibers, the nonwoven fabric may be formed of a mixture of the fibers, or the nonwoven fabric may be a laminate of layers formed of each fiber. A laminate can be prepared by, for example, laying one web on top of another, forming a web on a nonwoven fabric, or superposing nonwoven fabrics and joining them by embossing, etc.

The nonwoven fabric has a basis weight of 30 to 200 g/m^2, preferably 40 to 150 g/m^2, still preferably 50 to 130 g/m^2. It is difficult to form a uniform web having a basis weight of less than 30 g/m^2. A web having a basis weight of more than 200 g/m^2 would have too many thermally bonded joints of fibers only to provide firm and hard nonwoven fabric that has reduced tearability. Such a hard nonwoven fabric, when used as, for example, a cleaning sheet, will produce a poor lather of a detergent. Additionally, an

increased basis weight rises the production cost, making the nonwoven fabric unsuitable as a disposable article.

The nonwoven fabric has a thickness of 0.5 to 5 mm, preferably 1 to 3 mm. If the thickness is smaller than 0.5 mm, the distance of fibers making up the nonwoven fabric is short, and the web would have too many thermally bonded joints of fibers only to provide firm nonwoven fabric that has reduced tearability. Further, such a nonwoven fabric, when used as, for example, a cleaning sheet, will produce a poor lather of a detergent. If the thickness exceeds 5 mm, the distance between fibers will be too long to make sufficient number of thermally bonded joints for securing the strength of the nonwoven fabric. The term "thickness" of nonwoven fabric as referred to herein means a thickness measured under a load of 980 Pa (=10 gf/cm^2).

The nonwoven fabric has a tear strength of 0.1 to 3 N, preferably 1 to 2.5 N, as measured in at least one of planar directions. With a tear strength less than 0.1 N, the nonwoven fabric has insufficient strength. With a tear strength exceeding 3 N, the nonwoven fabric is not easily tearable with hand. It is particularly preferred for the nonwoven fabric to have a tear strength fallen within the above range in every planar direction of measurement. The tear strength can be measured by Elmendorf tear testing in accordance with JIS P8116 or K7128-2. Specifically, a test specimen 75±0.5 mm by 63±0.5 mm cut out of nonwoven fabric is set on a Elmendorf tear tester, a notch 20±0.5 mm long is cut in the middle of the longer side, and a tear test is carried out. A tear test is conducted five times for each of the machine direction and the transverse direction to obtain an average for each direction. In case where the tear strength of a single specimen is small, two or more thicknesses are subjected to the test. The tear strength is calculated according to equation:

$$\text{Tear Strength (mN)} = \frac{\text{Scale Reading(mN)}}{\text{Number of Specimens Torn Simultaneously} \times 16}$$

$$= \frac{9.81 \times \text{Scale Reading (gf)}}{\text{Number of Specimens Torn Simultaneously} \times 16}$$

The nonwoven fabric can be made easier to tear linearly by embossing in a continuous or discontinuous pattern. The embossed nonwoven fabric linearly tears easily when it is pull out of a dispenser by a desired length like a roll of wrapping film or aluminum foil put in a box. A continuous straight line pattern is preferred for satisfactory linear tearability. Embossing can be carried out by thermal embossing, ultrasonic embossing, and the like.

Fig. 1 is a representation of embossing in a checkered pattern, in which the sides of squares are in parallel with the machine direction and the transverse direction. The tearing position can be controlled by adjusting the degree of embossing as follows.

Where the nonwoven fabric is embossed so that the impressed fibers may be joined firmly to such an extent that they are not cut, the nonwoven fabric gains heightened strength at the impressed parts. As a result, the embossed nonwoven fabric tears at a position between two linearly impressed parts, i.e., along the dotted line indicated by encircled numeral 1 in Fig. 1. Since a tear may zigzag if the embossed pattern interval is too wide, a preferred pattern interval is 5 to 10 mm. The pattern interval being within 10 mm, the deviation of a propagating tear from the position expected from the initial tear can be limited within 10 mm. As a result, a piece of the nonwoven fabric can be torn off with more linearity, i.e., with no zigzag.

Where the nonwoven fabric is embossed with an embossing roll whose projections are kept at or above the melting point of the constituent fibers, the fibers in the impressed parts are melted in the thickness direction and cut to make depressions 2 (impressed parts) in the thickness direction of the nonwoven fabric 1 as shown in Fig. 2. The impressed parts, where the fibers have been cut, have a reduced tear strength so that the embossed nonwoven fabric may tear easily along the depression 2 and can be torn off with more linearity. The depressions 2 may be made in a continuous or discontinuous pattern according to desired tearability. In this embodiment, since a tear propagates through the depression 2, the interval of the depressions 2 has no influence on linear tearability unlike the embodiment shown in Fig. 1.

The embossed pattern is not limited to those shown in Figs. 1 and 2 and can include a

pattern of straight lines across the nonwoven fabric as shown in Fig. 3A, a pattern of dotted lines across the nonwoven fabric as shown in Fig. 3B, a pattern of zigzag lines across the nonwoven fabric as shown in Fig. 3C, a pattern of polka dots as shown in Fig. 3D, and a pattern of wavy lines across the nonwoven fabric as shown in Fig. 3E.

The nonwoven fabric of the present invention can be torn by hand to an arbitrary size. Therefore, it can be rolled up and put in a dispenser box like a roll of wrapping film or aluminum foil so that a desired length may be pull out and torn off as shown in Fig. 4A. A roll of the nonwoven fabric may be used as such or being put on a holder without a dispenser box. As shown in Fig. 4B, the nonwoven fabric can be folded like an accordion and put in a dispenser box, which is pulled out and cut on use. The nonwoven fabric may be used in the form of a stack of cut-to-size sheets as shown in Fig. 4C. In this case, a sheet of the nonwoven fabric can be torn by hand to smaller sizes as desired.

A piece of the nonwoven fabric can be torn to the size convenient for a user or folded into two or more to have an increased thickness convenient to use.

The nonwoven fabric according to the present invention is suitable as a cleaning sheet, a cooking sheet, a wiping sheet, and the like. More specifically, the nonwoven fabric can be used as a sponge-like sheet for cleaning a kitchen, a human body, a car body, etc. Since the nonwoven fabric can be torn to a necessary size, either small for cleaning a narrow gap or a small space or large for cleaning a large space, it is not only convenient to use but economical. A piece of the nonwoven fabric may be used as such or, if necessary, impregnated with a detergent or an abrasive-containing detergent to carry out a cleaning operation more effectively. The used piece of the nonwoven fabric may be reused, or when it becomes filthy or after it is used for removing dirt with offensive odors, it can be discarded.

For use as a cooking sheet or a wiping sheet, too, the nonwoven fabric can be torn by hand to a size fit for the particular use.

EXAMPLES

In the following Examples are described several preferred embodiments to illustrate the present invention in greater detail. It is to be understood that the present invention is not deemed to be limited to these specific embodiments.

EXAMPLE 1

Thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polypropylene/polyethylene; length: 5 mm; fineness: 3 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

EXAMPLE 2

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 10 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

EXAMPLE 3

Thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polypropylene/polyethylene; length: 5 mm; fineness: 32 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

EXAMPLE 4

Four plies of the nonwoven fabric prepared in Example 2 were stacked on each other and heat-embossed in a checkered pattern to obtain a laminated nonwoven fabric. The distance between adjacent lines of the pattern was 10 mm.

EXAMPLE 5

The nonwoven fabric prepared in Example 2 and the nonwoven fabric prepared in Example 3 were superposed and heat-embossed in a checkered pattern to obtain a laminated

nonwoven fabric. The distance between adjacent lines of the pattern was 10 mm.

EXAMPLE 6

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 5 d) and thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 10 d) were mixed at a weight ratio of 1:1, and the mixed fibers were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

EXAMPLE 7

Rayon fibers (length: 5 mm; fineness: 3 d) were air-laid into a web. A polyethylene powder (Mitsui Hi-Wax 320MP (trade name), available from MITSUI CHEMICAL CO., LTD.; melting point: 122°C) was scattered thereon in an amount of 20% by weight based on the rayon fibers. The web was passed through a hot air drier to thermally bond the intersections of the fibers by powder bonding to obtain a nonwoven fabric.

EXAMPLE 8

Thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polypropylene/polyethylene; length: 5 mm; fineness: 65 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 80 g/m^2.

EXAMPLE 9

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 10 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 200 g/m^2.

EXAMPLE 10

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 6 d) and thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polypropylene/polyethylene; length: 5 mm; fineness: 65 d) were mixed at a weight ratio of 1:1, and the mixed fibers were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 100 g/m^2.

EXAMPLE 11

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 6 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 40 g/m^2. Thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polypropylene/polyethylene; length: 5 mm; fineness: 65 d) were built-up on the web by air-laying to form a web having a basis weight of 80 g/m^2. The laminated web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a laminated nonwoven fabric having a basis weight of 120 g/m^2.

EXAMPLE 12

Thermally fusible fibers (eccentric core/sheath type conjugate fibers; core/sheath: polyethylene terephthalate/polyethylene; length: 5 mm; fineness: 8 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 50 g/m^2.

EXAMPLE 13

Polyethylene terephthalate fibers (length: 5 mm; fineness: 10 d) were air-laid into a web. A polyethylene powder (Mitsui Hi-Wax 320MP (trade name), available from MITSUI CHEMICAL CO., LTD.) was scattered thereon in an amount of 20% by weight based on the fibers. The web was passed through a hot air drier to thermally bond the intersections of the fibers by powder bonding to obtain a nonwoven fabric having a basis weight of 60 g/m^2.

EXAMPLE 14

The nonwoven fabric prepared in Example 1 and the nonwoven fabric prepared in Example 2 were superposed and heat-embossed in a checkered pattern to obtain a laminated nonwoven fabric having a basis weight of 100 g/m^2. The distance between adjacent lines of the pattern was 10 mm.

EXAMPLE 15

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 6 d) and thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 10 d) were mixed at a weight ratio of 1:1, and the mixed fibers were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a basis weight of 100 g/m^2.

COMPARATIVE EXAMPLE 1

Five plies of the nonwoven fabric prepared in Example 2 were stacked on each other and heat-embossed in a checkered pattern to obtain a laminated nonwoven fabric having a basis weight of 250 g/m^2. The distance between adjacent lines of the pattern was 10 mm.

COMPARATIVE EXAMPLE 2

The nonwoven fabric obtained in Example 2 was sandwiched between a pair of metal plates and heated in a drier under a load to thermally bond the intersections of the fibers to obtain a nonwoven fabric having a thickness of 0.4 mm.

COMPARATIVE EXAMPLE 3

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 20 mm; fineness: 10 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

COMPARATIVE EXAMPLE 4

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 5 mm; fineness: 0.8 d) were air-laid into a web. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

COMPARATIVE EXAMPLE 5

Commercially available spun-bond nonwoven fabric of polypropylene (Syntex PS108, available from MITSUI CHEMICAL CO., LTD.) was used.

COMPARATIVE EXAMPLE 6

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 50 mm; fineness: 3 d) were made into a web by carding. The web was passed through a hot air drier to thermally bond the intersections of the fibers to obtain a nonwoven fabric.

COMPARATIVE EXAMPLE 7

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 50 mm; fineness: 3 d) were fabricated into a nonwoven fabric by spun-lacing (water needling method).

COMPARATIVE EXAMPLE 8

A nonwoven fabric was obtained in the same manner as in Example 2, except for changing the basis weight to 250 g/m^2.

COMPARATIVE EXAMPLE 9

Thermally fusible fibers (side-by-side type conjugate fibers; inner/outer: polypropylene/polyethylene; length: 50 mm; fineness: 3 d) were made into a web by carding. The web was passed through a hot air drier to thermally bond the intersections of the fibers

to obtain a nonwoven fabric having a basis weight of 40 g/m^2.

COMPARATIVE EXAMPLE 10

A commercially available scourer made of nylon (a product of WHEAT K.K.) was used. This is an article prepared by making a web of nylon fibers (length: 5 mm; fineness: 20 d) by carding, needle-punching the web and coating the web with an abrasive-containing resin.

Performance Evaluation-1:

The nonwoven fabrics prepared in Examples and Comparative Examples were evaluated for the physical properties and tearability, and the results obtained are shown in Tables 1 and 2 below. Of the attributes shown in the Tables, measurement of tear strength and evaluation of tearability were made as follows.

Tear Strength:

An Elmendorf tear test was carried out according to the above-described method. In cases where a tear did not propagate from the notch straight in the width direction but ran in the direction perpendicular to the width direction, the nonwoven fabric was judged "untearable".

Tearability:

A test piece 10 cm by 10 cm was cut out of the nonwoven fabric with the sides thereof in parallel with the machine direction and the width direction. The test piece was torn apart by hand, and the tearability was organoleptically evaluated. Five testers conducted the test and rated the tearability on a one-to-three scale: tearable with light force; tearable with strong force; or untearable. The results of rating were judged as follows.

Good :All the five testers could tear, and three or more testers out of five could tear with light force.

Medium :All the five testers could tear, and two or less testers could tear with light force.

Poor :At least one tester could not tear.

Performance Evaluation-2:

The nonwoven fabrics prepared in Examples and Comparative Examples were evaluated for the performance in actual use as a cleaning sheet. The nonwoven fabrics of Examples 1 to 3, 5, and 8 to 13 and Comparative Examples 5, 7, 9 and 10 were used for kitchen cleaning. Those of Examples 1, 2, 9, and 12 to 15 and Comparative Examples 5, 7, and 9 were used for washing a human body. Those of Examples 1 to 3, 5, and 8 to 13 and Comparative Examples 5, 7, and 9 were used for washing a car body. The cleaning performance in the kitchen use was evaluated in terms of detergent lathering properties, dirt scouring properties, and ease of use. The cleaning performance in the use on a human body and a car body was evaluated in terms of detergent or soap lathering properties, non-scratching properties, and ease of use. The results obtained are shown in Tables 3 through 5. The methods of evaluation are as follows.

Lathering Properties:

a) In the kitchen

A commercially available dishwashing detergent (Family Fresh 1/2 (trade name), available from Kao Corporation) was dissolved in tap water to a concentration of 1.25% by weight to prepare a diluted detergent for a test of lathering. In a transparent acrylic resin cylinder (available from SUNPLATEC CORP.; inner diameter: 133 mm; height: 45 cm) was put 30 ml of the diluted detergent. The nonwoven fabric was put in the cylinder and crumpled by hand for 1 minute to work up a lather. Thereafter, the lather attached to the hand and the inner wall of the cylinder was washed down with 500 ml of tap water. After the lather was leveled and allowed to stand for 30 seconds, the thickness of the lather layer (the height of the lather layer from the water level) was measured by observing from the side of the cylinder, which was taken as a measure of lathering properties.

Seeing that commercially available urethane sponge goods 75 mm wide and 110 mm long (and several millimeters thick) are easy to use, this size was adopted in testing the nonwoven fabric. The same test was carried on a piece 110 mm by 150 mm as folded in two and a piece 150 mm by 220 mm as folded in four.

The piece of the nonwoven fabric was also evaluated for the property of restoring the original shape after the above testing (after being crumpled). Samples which restored the original shape were judged "good", and those which remained curled "poor".

b) On the human body or the car body

One gram of a commercially available body soap (Biore U (trade name), supplied by Kao Corporation) or a commercially available car washing detergent (White Car Shampoo (trade name), supplied by JOHNSON & JOHNSON K.K.) was applied to a test piece of the nonwoven fabric 100 mm by 100 mm having been wetted with water, and the test piece was repeatedly crumpled by hand.

The lather thus worked up was organoleptically evaluated by five testers on a one-to-three scale: good, medium, and poor (the detergent or soap did not lather because the nonwoven fabric was curled). The scale at which the testers placed a sample piece the most was taken as a scale of that sample piece. In case where a sample was placed at two scales each by two testers, the two scales are shown in the Tables.

Ease of Use:

Five testers were asked to wash dishes, their bodies and a car body with a test piece of the nonwoven fabric impregnated with a dishwashing detergent, a body soap or a car washing detergent and to rate the ease in grasping in a hand and the conformability to the curved surface of the object of cleaning on the following scale. The scale at which the testers placed a sample piece the most was taken as a scale of that sample piece. In case where a sample was placed at two scales each by two testers, the two scales are shown in the Tables.

a) Ease in grasping

Good	:Easy to grasp
Medium	:Not so easy to grasp
Poor	:Not easy to grasp (because the nonwoven fabric slipped off the hand)

b) Conformability to curved surface

Good	:Conformable
Medium	:Less conformable
Poor	:Not conformable

Dirt Scouring Properties:

A 5:1 (by weight) mixture (0.06 g) of rapeseed oil and carbon black was uniformly spread on an iron plate 30 mm wide, 80 mm long and 1 mm thick and denatured at 150°C for 50 minutes.

The iron plate thus stained was fixed on a wear tester, and a load to be applied was set at 1 kg. A strip 7.5 mm by 50 mm of the nonwoven fabric lightly wetted with water was affixed to a swinging part and swung to give the stained iron plate 200 double strokes. The iron plate was washed with water and dried, and the degree of stain removal was observed with the naked eye and rated as follows.

Very Good	:The stain was almost removed.
Good	:The stain was fairly removed.
Medium	:The stain was slightly removed.
Poor	:The stain was hardly removed.

Non-Scratching Properties:

The skin or a car body was rubbed with the nonwoven fabric by hand to see with the naked eye whether or not the rubbing gave scratches to the skin or the car body. The judgement includes "good" (no scratches were given) or "poor" (scratches were given).

TABLE 1

Example No.	Web Forming Method	Fiber Length (mm)	Fiber Fineness (d)	Basis Weight (g/m^2)	Thickness (mm)	Distance Between Fibers (μm)	Specific Capacity (cm^3/g)	Tear Strength (mN)		Tearability	
								MD	TD	MD	TD
1	air-laying	5	3	60	2.3	113	38.3	1553	1492	good	good
2	air-laying	5	10	50	1.9	206	38.0	576	607	good	good
3	air-laying	5	32	60	1.8	327	30.0	926	824	good	good
4	air-laying	5	10	200	4.9	165	24.5	2300	2428	good	good
5	air-laying & laminating Exs.2 and 3	5 5	10 32	50 60	2.4	200 320	21.8	1176	1332	good	good
6	air-laying of mixed fibers	5 5	5 10	30 30	1.9	153	31.7	1520	1490	good	good
7	air-laying	5	3	60	1.5	91	25.0	2310	2430	good	good
8	air-laying	5	65	80	3.1	524	38.8	805	755	good	good
9	air-laying	5	10	200	4.1	151	20.5	2300	2428	good	good
10	air-laying of mixed fibers	5 5	6 65	50 50	2.3	168	23.0	1344	1320	good	good
11	air-laying & laminating	5 5	6 65	40 80	3.0	190 450	25.0	1530	1588	good	good
12	air-laying	5	8	50	2.0	189	40.0	2330	2150	good	good
13	air-laying	5	10	60	2.0	193	33.3	1800	2030	good	good
14	air-laying & laminating by embossing	5 5	3 10	50 50	3.5	100 200	35.0	2010	2038	good	good
15	air-laying of mixed fibers	5 5	6 10	50 50	3.2	129	20.0	1250	1390	good	good

TABLE 2

Compa. Example No.	Web Forming Method	Fiber Length (mm)	Fiber Fineness (d)	Basis Weight (g/m^2)	Thickness (mm)	Distance Between Fibers (μm)	Specific Capacity (cm^3/g)	Tear Strength (mN)		Tearability	
								MD	TD	MD	TD
1	air-laying	5	10	250	6.1	165	24.4	3100	3035	medium	medium
2	air-laying	5	10	50	0.4	94	8.0	3520	4110	medium	medium
3	air-laying	20	10	50	1.8	200	36.0	1050	Untearable	good	poor
4	air-laying	5	0.8	60	2.0	54	33.3	3110	3091	medium	medium
5	spun-bonding	∞	2.6	40	0.3	47	7.5	5227	Untearable	medium	poor
6	carding	50	3	25	0.6	89	24.0	1114	Untearable	good	poor
7	carding/ spun-lacing	50	3	40	0.4	58	10.0	1422	Untearable	good	poor
8	air-laying	5	10	250	5.1	151	20.4	3100	3050	medium	medium
9	carding	50	3	40	1.0	91	25.0	5227	Untearable	medium	poor
10	carding/needle punching	50	20	360	5.0	176	13.9	untearable	Untearable	poor	poor

TABLE 3

Performance as Cleaning Sheet in Kitchen

		Fold	Lathering Properties		Dirt Scouring Properties	Ease of Use	
			Lather Height (mm)	Shape Resto-ration		Ease of Grasping	Conform-ability
Example	1	-	17	good	good	good	good
		folded in 2	19	good		good	good
		folded in 4	25	good		good	good
	2	-	17	good	good	good	good
		folded in 2	22	good		good	good
		folded in 4	25.5	good		good	good
	3	-	18	good	good	good	good
		folded in 2	19	good		good	good
		folded in 4	26.5	good		good	good
	5	-	20	good	10-d side: good 32-d side: very good	good	good
	8	-	22	good	good	good	good
		folded in 2	26	good		good	good
		folded in 4	28	good		good	good
	9	-	30.5	good	good	good	good
	10	-	20	good	good	good	good
	11	-	23	good	6-d side: good 65-d side: very good	good	good
	12	-	22	good	good	good	good
	13	-	20	good	good	good	good
Comp. Example	5	-	11	poor	poor	poor	good
		folded in 2	12.5	poor		poor	good
		folded in 4	13	poor		poor	good
	7	-	10	poor	poor	poor	good
		folded in 2	11	poor		poor	good
		folded in 4	13	poor		poor	good
	9	-	13	poor	medium	poor	good
		folded in 2	15	poor		medium	good
		folded in 4	16	poor		medium	good
	10	-	23	good	very good	good	medium

TABLE 4

Performance as Cleaning Sheet on Human Body

		Lathering Proper-ties	Non-Scratch-ing Properties	Ease of Use	
				Ease of Grasping	Conformability
Example	1	good	good	good	good
	2	good	good	good	good
	9	good	good	good	good
	12	good	good	good	good
	13	good	good	good	good
	14	good	good	good	good
	15	good	good	good	good
Compa. Example	5	poor	good	poor	good
	7	poor	good	poor	good
	9	medium	good	medium	good

TABLE 5

Performance as Cleaning Sheet on Car Body

		Lathering Properties	Non-Scratching Properties	Ease of Use	
				Ease of Grasping	Conform-ability
Example	1	good	good	good	good
	2	good	good	good	good
	3	good	good	good	good
	5	good	10-d side: good 32-d side: good	good	good
	8	good	good	good	good
	9	good	good	good	good
	10	good	good	good	good
	11	good	6-d side: good 65-d side: good	good	good
	12	good	good	good	good
	13	good	good	good	good
Compara. Example	5	poor	good	poor	good
	7	poor	good	poor	good
	9	medium	good	medium	good

As is apparent from the results in Tables 1 and 2, the nonwoven fabrics of the present invention which are prepared by the air-laying method using fibers having a specific length and a specific fineness and which have a specific basis weight, a specific thickness, and a specific tear strength are easy to tear by hand with no anisotropy in tearability as compared with the comparative nonwoven fabrics. In particular, the nonwoven fabrics of Examples 4 and 5, being heat embossed in a checkered pattern and having an increased strength at the impressed parts, show tearability with high linearity between the impressed parts.

As is shown in Table 3, where the nonwoven fabrics of the present invention are used as a cleaning sheet in the kitchen, they are excellent in making a detergent lather well, proving capable of performing the function as a sponge. Particularly where they are used as folded in two or four to have an increased capacity, the lathering properties are improved with significant difference. The nonwoven fabrics of Examples are excellent in the property of restoring the shape after lathering, which also demonstrates that they have the function as a sponge.

The dirt scouring properties are improved as the fineness of the fibers increases as can be seen from the results of Examples 5, 10, and 11. The nonwoven fabrics of Examples 5 and 11 have on one side thereof a web made up of thick fibers, and the nonwoven fabric of Example 10 contains thick fibers in a mixed state. Although the commercially available nylon scourer of Comparative Example 10 is excellent in lathering properties and scouring properties, it is hard, less conformable to the shape of an object of cleaning, and untearable with hand.

Every cleaning sheet of Examples can be torn by hand to a desired size fit for a user in washing dishes and kitchen utensils. The cleaning sheet can be torn off to a smaller piece fit for cleaning corners or narrow gaps, which is greatly convenient and advantageous.

As is shown in Table 4, where the nonwoven fabrics of the present invention are used as a cleaning sheet for a human body, they make soap lather well and are satisfactory in washing the body therewith while preventing skin irritation by having the fineness of the constituent fibers adjusted. The nonwoven fabrics of Comparative Examples 5, 7, and 9 do not make soap lather well and are not easy to grasp because they slip off the hand. Since the cleaning sheets of Examples are tearable at any length, they can be torn off, for example, in a towel size convenient for washing up the back.

As is shown in Table 5, where the nonwoven fabrics of the present invention are used as a cleaning sheet for a car body, they make detergent lather well and are prevented from scratching the car body by having the fineness of the constituent fibers adjusted. The nonwoven fabrics of Comparative Examples 5, 7, and 9 do not make detergent lather well and are not easy to hold because they slip off the hand. Since the cleaning sheets of Examples are tearable by hand at any length, they can be torn off at a large length to wash the car efficiently.

Application examples of the nonwoven fabric prepared in the foregoing Examples are shown below. When each of the nonwoven fabrics of Examples was used as a kitchen sponge, a dishwashing detergent infiltrated therein lathered well. When each of the nonwoven fabrics of Examples was cut in about the size of a kitchen sponge (11 cm x 7.5 cm) and used to wash dishes such as plates and cups and kitchen utensils such as a frying pan, the user could press the nonwoven fabric, which was a sheet, against these objects with ease and washed off the dirt or stains in narrow gaps. Because the nonwoven fabrics of Examples 3 and 5 have thick fibers and thereby produce a high scouring effect, it was easy to scour out stubborn dirt or scorches with these nonwoven fabrics. With these nonwoven fabrics torn into a small piece, the corners or narrow spaces of a stove, a broiler, etc. could be cleaned easily. For use in cooking, each of the nonwoven fabrics of Examples, torn into a piece of convenient size to use, could be used for washing the dirt off root vegetables like potatoes and white radishes or for peeling boiled potatoes while hot with ease. Each of the nonwoven fabrics of Examples could be used as cut to the size of a saucepan and put on a food while cooked like a floating lid, or could be used as cut into a small piece and held between chopsticks to remove impurities or fat generated from meat or vegetables while boiled.

As described above in detail, the present invention provides nonwoven fabric that can easily be torn to an arbitrary size by hand. The present invention also provides nonwoven fabric that has no difference in tearability between the machine direction and the transverse direction. The present invention further provides sponge-like nonwoven fabric that is suitable as a cleaning sheet which exhibits both detergent lathering properties and dirt scouring properties and is convenient to use. The present invention furthermore provides sponge-like nonwoven fabric suitable as a cleaning sheet which is conformable to the contour of an object of cleaning.

Obviously, the present invention is subject to many modifications and variations in the light of the above teachings. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described within the scope and spirit of the appended claims.

This application claims the priority of Japanese Patent Application Nos. 11-158314 filed June 4, 1999 and 11-194933 filed July 8, 1999 which are incorporated herein by reference.